TMDL and Stream Restoration – Coastal Plain

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Virginia Department of Environmental Quality

Agenda

- SLAF Program
  - (Stormwater Local Assistance Fund)
- MS4 Permitting
  - (Municipal Separate Storm Sewer Systems)
- Nutrient and Sediment Reduction Efficiency
- Project Verification Post Monitoring

Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects

Joe Berg, Josh Burch, Deb Cappuccitti, Solange Filoso, Lisa Fraley-McNeal, Dave Goerman, Natalie Hardman, Sujay Kaushal, Dan Medina, Matt Meyers, Bob Kerr, Steve Stewart, Bettina Sullivan, Robert Walter and Julie Winters

Accepted by Urban Stormwater Work Group (USWG): **February 19, 2013**
Approved by Watershed Technical Work Group (WTWG): **April 5, 2013**
Final Approval by Water Quality Goal Implementation Team (WQGIT): **May 13, 2013**
Test-Drive Revisions Approved by the USWG : **January 17, 2014**
Test-Drive Revisions Approved by the WTWG: August 28, 2014
Test-Drive Revisions Approved by the WQGIT: September 8, 2014

Prepared by:
Tom Schueler, Chesapeake Stormwater Network
and
Bill Stack, Center for Watershed Protection

Also known as *Expert Panel Report*

DEQ SLAF Program - Stream Restoration

- 2017 - $20 million (41 total projects 24 were stream restoration)
- 2019 - $20 million (24 total projects 21 were stream restoration)

- Currently:
- State spending funding only on projects that:

  1. Meet Expert Panel Report requirements
  2. Have appropriate site selection (DEQ approved), preliminary stream restoration plan review, site visits during construction and final walk through.
  3. Mandatory monitoring of sites – Yearly monitoring requirements mimicking other programs at DEQ

Choosing a proposed Stream Restoration Project for SLAF

- Meet Basic Qualifying Conditions in Expert Panel Report section 4.2 and 4.3
  - Tidal streams do not qualify under the Expert Panel Report

  - Preliminary site visits not required but are highly recommended to save time and money
    - Site visit may be warranted after DEQ desktop review

  - Final nutrient crediting must be derived from Bank Assessment for Nonpoint Source Consequences of Sediment (BANCS)

Expert Panel Report section 4.2 and 4.3 summary used by DEQ

<u>Recommended Basic Qualifying Conditions for Stream Restoration Projects</u>

(Berg, et al, *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects*, September 8, 2014)

- ☐ Watershed based approach to identify streams or reaches of greatest restoration need.
- ☐ Project does not solely consist of measures to protect public infrastructure through bank armoring, rip rap, or limited bank stabilization, which may need to be mitigated.
- ☐ Project's sole purpose is not nutrient and sediment reduction, but is a carefully designed intervention to improve hydrologic, hydraulic, geomorphic, water quality, and/or biological condition on a degraded stream.
- ☐ Project is located in a moderately to severely degraded stream system, as evidenced by one or more of the following:
    - Functional stream assessment (Harman et al (2011), or functional equivalent)
    - Geomorphic evidence of active stream degradation (stream type, BEHI scores, etc.)
    - An IBI of fair or worse
    - Hydrologic evidence of floodplain disconnection
    - Evidence of significant depth of legacy sediment

- ☐ Project promotes nutrient uptake or denitrification through one or more of the following:
  - Reconnects the stream with its floodplain and/or increases retention time in floodplain
    - Protocol 2 - Bank Height Ratio = or < 1.0;
    - Protocol 3 - Suggested watershed to floodplain surface area ratio of at least 1.0%;
  - Creates floodplain wetlands and/or increases retention time in floodplain wetlands;
  - Adds dissolved organic carbon (i.e. instream debris jams, instream woody debris, or re-exposing hydric soils in the pre-settlement floodplain);
  - Reconnect stream to floodplain/wetlands during both dry-weather and storm flows (i.e. low floodplain benches, sand seepage wetlands, legacy sediment removal, etc.);
- ☐ Project is greater than 100 linear feet in length and still actively enlarging or degrading in response to previous disturbances in the watershed (i.e. road crossing, failing dam, etc.)
- ☐ Project is located on a first- to third- order stream system. Some fourth- or fifth-order systems may be appropriate, if they are shown to contribute significant and uncontrolled amounts of sediment and nutrients to downstream waters.
- ☐ If using Natural Channel Design, the proposed stream design is appropriate for the valley type, geographic region, and is a natural channel evolution of the existing geomorphic parameters.
- ☐ If using the BANCS method to show the amount of sediment contribution, the project also uses the Natural Channel Design stream restoration approach (as opposed to LGS, RSC, etc.).
- ☐ Protocol 2 - Project is not located on bedrock outcroppings or confining clay layers.
- ☐ Project addresses long-term stability of the channel, banks, and floodplain.
- ☐ Project maintains or expands existing riparian buffer corridors.
- ☐ Upstream BMPs are proposed or implemented in the watershed, to reduce runoff and stormwater pollutants and improve low flow hydrology.

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Data needed for BANCS summary

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use Figure 3-7 with BEHI variables to determine BEHI score.

Stream: Location:
Station: Observers:
Date: Stream Type: Valley Type:

				BEHI Score (Fig. 3-7)
Study Bank Height / Bankfull Height (C)				
Study Bank Height (ft) = (A)	Bankfull Height (ft) = (B)	(A) / (B) = (C)		
Root Depth / Study Bank Height (E)				
Root Depth (ft) = (D)	Study Bank Height (ft) = (A)	(D) / (A) = (E)		
Weighted Root Density (G)				
Root Density as % = (F)	(F) x (E) = (G)			
Bank Angle (H)				
Bank Angle as Degrees = (H)				
Surface Protection (I)				
Surface Protection as % = (I)				

Bank Material Adjustment:
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	

Bank Sketch

Root

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: Location:
Station: Stream Type: Valley Type:
Observers: Date:

Methods for Estimating Near-Bank Stress (NBS)

(1) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconnaissance
(2) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(3) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(5) Ratio of near bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(7) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I (1): Transverse and/or central bars-short and/or discontinuous ... NBS = High / Very High; Extensive deposition (continuous, cross-channel) ... NBS = Extreme; Chute cutoffs, down-valley meander migration, converging flow ... NBS = Extreme

Level II:
(2) Radius of Curvature R_c (ft) | Bankfull Width W_{bkf} (ft) | Ratio R_c / W_{bkf} | Near Bank Stress (NBS)
(3) Pool Slope S_p | Average Slope S | Ratio S_p / S | Near Bank Stress (NBS)
(4) Pool Slope S_p | Riffle Slope S_{rif} | Ratio S_p / S_{rif} | Near-Bank Stress (NBS)

Dominant Near-Bank Stress

Level III:
(5) Near-Bank Max Depth d_{nb} (ft) | Mean Depth d_{bkf} (ft) | Ratio d_{nb} / d_{bkf} | Near-Bank Stress (NBS)
(6) Near-Bank Max Depth d_{nb} (ft) | Near-Bank Slope S_{nb} | Near-Bank Shear Stress τ_{nb} (lb/ft^2) | Mean Depth d_{bkf} (ft) | Average Slope S | Bankfull Shear Stress τ_{bkf} (lb/ft^2) | Ratio τ_{nb} / τ_{bkf} | Near Bank Stress (NBS)

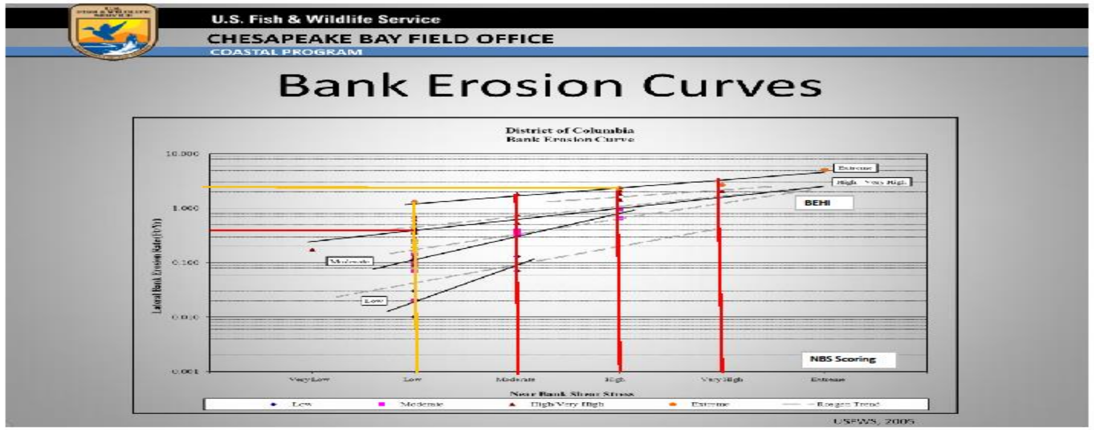
Level IV:
(7) Velocity Gradient (ft / sec / ft) | Near-Bank Stress (NBS)

Stress (NBS) Rating
ethod number

(4)	(5)	(6)	(7)
< 0.40	< 1.00	< 0.80	< 0.50
0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
> 1.20	> 3.00	> 1.60	> 2.40

Stress (NBS) rating

River Stability Field Guide page 3-72



Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

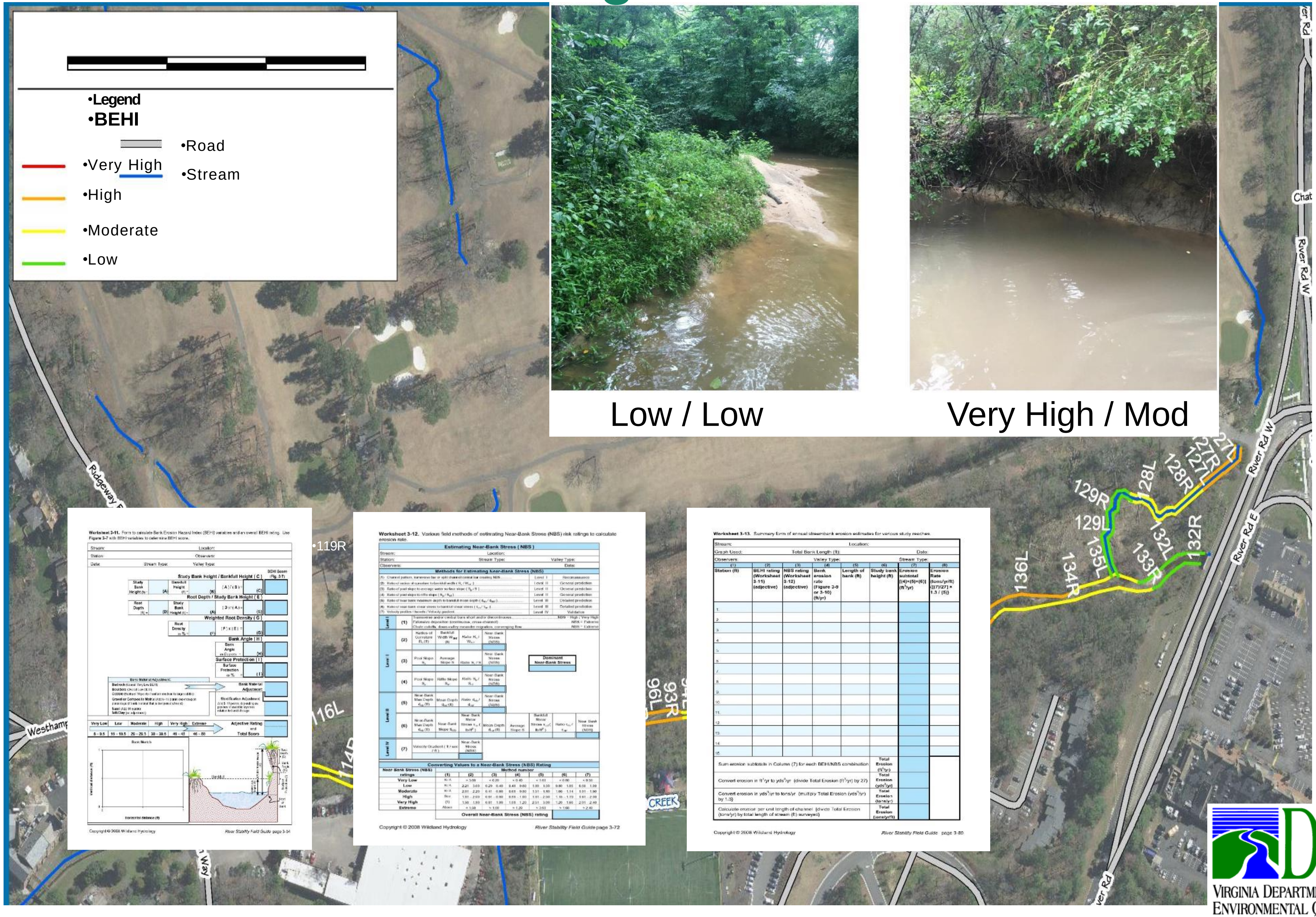
Stream: Location:
Graph Used: Total Bank Length (ft): Date:
Observers: Valley Type: Stream Type:

(1) Station (ft)	(2) BEHI rating (Worksheet 3-11) (adjective)	(3) NBS rating (Worksheet 3-12) (adjective)	(4) Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	Total Erosion (ft^3/yr)	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}	Total Erosion (yds^3/yr)	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}	Total Erosion (tons/yr)	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}	Total Erosion (tons/yr/ft)	

Copyright © 2008 Wildland Hydrology *River Stability Field Guide* page 3-89

Presenting BANCS data



Low / Low

Very High / Mod

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Stream Restoration is challenging in the Coastal Plain

- Topographical restraints
- Elevated water table
- Relying on BANCS assessment for final nutrient crediting
    - Most streams are connected to floodplain (low erosion)

New crediting alternative

- Protocol 5 – Outfall and Gully Stabilization

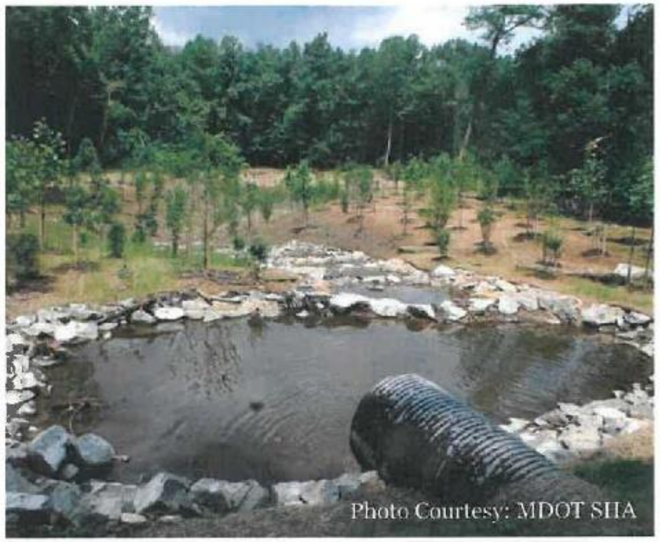
DEQ

Final Memo

Water Quality Goal Implementation Team Approved:

October 15, 2019

Recommendations for
Crediting Outfall and Gully Stabilization Projects
in the Chesapeake Bay Watershed



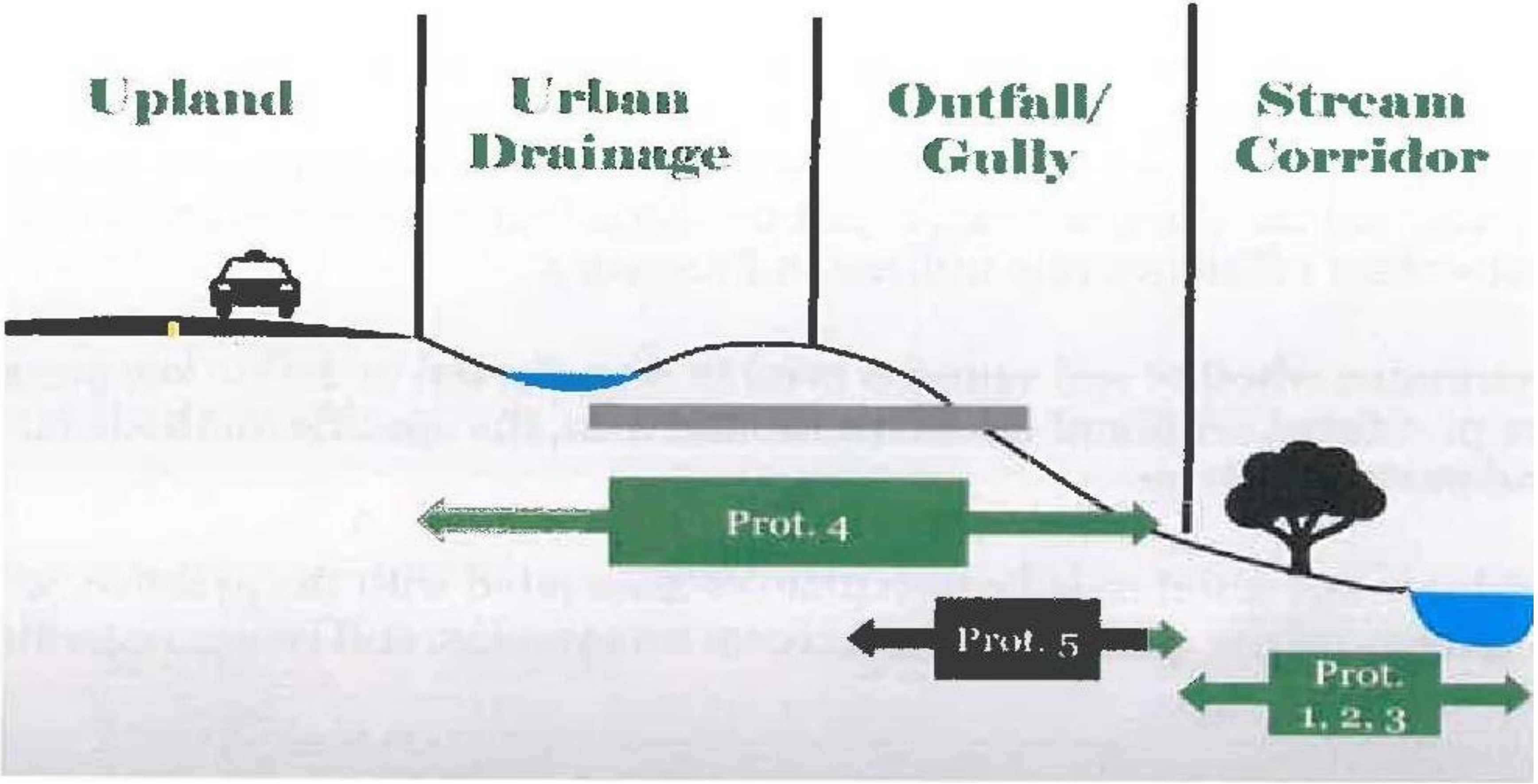
Stream Restoration Group 2:

Ray Bahr, Aaron Blair, Ted Brown, Karen Coffman,
Ryan Cole, Tracey Harmon, Erik Michelsen, Nick Noss,
Elizabeth Ottinger, Brock Reggi, Stephen Reiling,
Allison Santoro, Chris Stone,
Carrie Traver and Neil Weinstein

Date: October 15, 2019

https://www.chesapeakebay.net/channel_files/37043/approval_draft_outfall_restoration_memo_070119.pdf

Protocol 5



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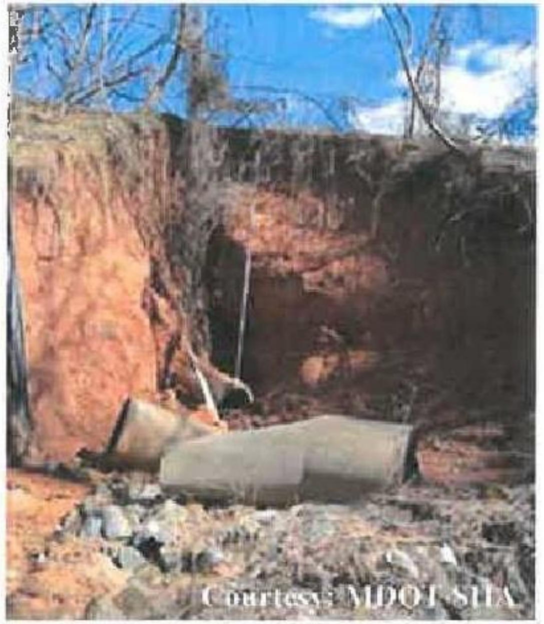
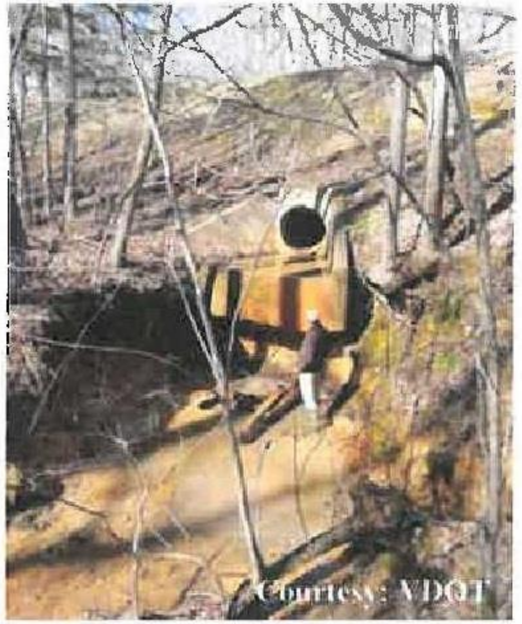
1.



2.



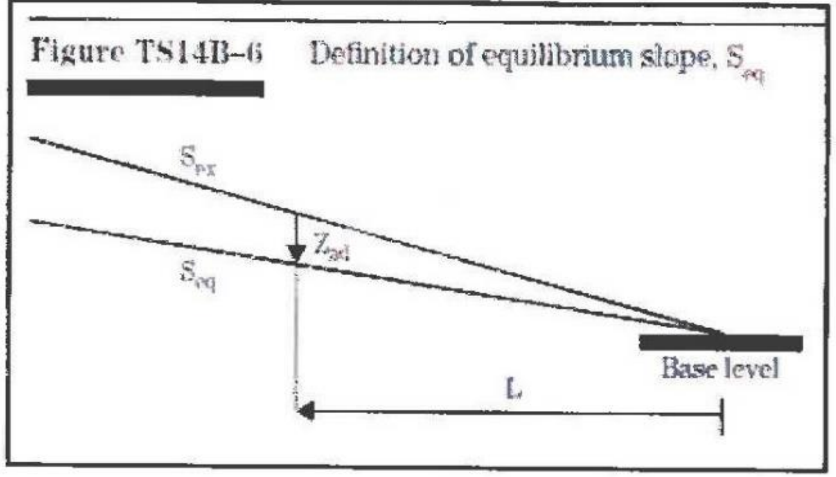
3.

4.

1. Extremely incised vertical walls with failed outfall structure.
2. Eroding channel and threatened outfall structure caused by migrating knickpoint.
3. Highly incised and widened outfall channel caused by migrating headcut.
4. Eroding roadway embankment with severe incision and threatened infrastructure.

PROTOCOL QUICK SUMMARY

Base level & Equilibrium Slope



CALCULATE THE FUTURE SURFACE DEPENDENT UPON TWO KEY PARAMETERS

Equilibrium Slope: *When sediment transport capacity exceeds sediment supply, channel degradation occurs until an armor layer forms that limits further degradation or until the channel bed slope is reduced so much that the boundary shear stress is less than a critical level needed to entrain the bed material.*

Comparative Cross Section

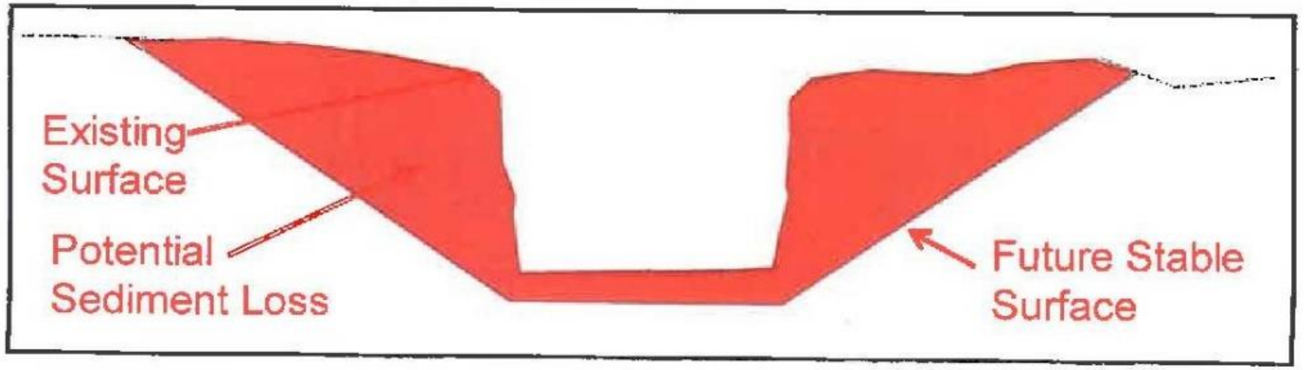


Table 5. Comparison of Sediment Reduction Potential for the Three Protocols					
Sediment Reduction Protocol	Typical Reach Length	Default	Min	Mean	Max
	ft	lbs of sediment per linear ft restored [1]			
Protocol 1	1000 to 4000	248	3	375	3,750
Protocol 4	100 to 300	NA	5	7	8
Protocol 5	50 to 500	NA	40	1,060	17,300

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Table 5. Comparison of Sediment Reduction Potential for the Three Protocols					
Sediment Reduction Protocol	Typical Reach Length	Default	Min	Mean	Max
	ft	lbs of sediment per linear ft restored [1]			
Protocol 1	1000 to 4000			375	
Protocol 4					
Protocol 5	50 to 500			1,060	

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PRE-RESTORATION		POST-RESTORATION
	• Drop Structure • Step Pool Pattern	
	• Rock Outlet Protection	
	• Step Pool Sequence • Vegetative Plantings	

- Plunge Pool
- Step Pool Structures

- Retaining Wall
- Concrete Pipe
- Rip Rap Plunge Pool

DEQ MS4 Program – Stream Restoration

2019:

- 188 projects completed or proposed (combined TMDL action plans 2013-2023)
- TSS: 11,580,478 lbs/yr
- P: 25,228 lbs/yr
- N: 51,382 lbs/yr

Action Plan Guidance update

- The guidance will be an updated version of the existing guidance document. It will include credit calculations and examples of the BMPs most commonly used by MS4s in Virginia.
- Please note that it is possible to use any BMP with in the approved Chesapeake Bay Program for crediting purposes.
- DEQ will also consider any new BMPs/Practices or existing BMPs used in new and innovative ways. (for example, using wood chip bioreactors to treat storm water)

MS4 Nutrient and Sediment Reductions Moving Forward

- For Stream Restoration DEQ currently accepting Revised Default Rates for final credit evaluations, but requiring the use of Protocols from Expert Panel after Action Plan Guidance Update.

- Grandfathering older projects utilizing Revised Default Rates

Data needed for updated Action Plan Guidance for MS4 Stream Restoration site selection

- Meet Basic Qualifying Conditions in Expert Panel Report
  - Section 4.2 and Section 4.3
- Photographs
- Rationale for why project should be constructed
- Evidence of prioritization for the stream selection
- Accepting preliminary design plans
- Demonstration of Nutrient calculations from Protocols (BANCS)
- Currently no on site review required by DEQ staff, but strongly advised

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Examples of standard data DEQ would be looking for on a design map review:

- Photographs documenting current conditions
- Typical riffle/pool cross-sections (width, max depth, mean depth, area)
- Plan, profile, and cross-sections on design elevations
- Design Summary with morphological data
- Reference data or supporting evidence
- H&H data showing shears and velocities
- Substrate sizing
- Structure Details

Monitoring constructed projects

- MS4 action plan update for stream restoration BMP monitoring utilizing section 7.1 of the Expert Panel Report
  - As-built
  - Photographs of completed project
  - Visual monitoring
  - Data required for BMP Warehouse records
  - All monitoring required by regulatory agencies per permit

- DEQ is currently working to removing the use of Stream Restoration under the Corps NW-43
  - NW-43 does not require monitoring

- Stream Restoration BMP monitoring in Virginia
  - Standard surveyed monitoring of years 1,2,**3**&5

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Suggested monitoring plan for MS4 Stream Restoration projects:

- Cross-section data
    - Bank Height Ratio
    - Width Depth Ratio
    - Cross-sectional area changes
- Vegetation
    - Live stake
    - Bare ground / herbaceous
    - Native stem density
- Material stability
    - D50 remains within approved as-built size class
- Structure stability
    - Absence of collapsed structure or repositioned header rock
    - Absence of under cutting, wash around, or erosion of the bank or streambed

- Re-evaluate BANCS at year 3 (verify **Protocol 1 Efficiency's**)

Protocol 1 Efficiency

- "The Panel concluded that the mass load reductions should be discounted to account for the fact that **projects will not be 100% effective** in preventing stream bank erosion and that some sediment transport occurs naturally in a stable stream channel."

- "Consequently, the Panel took a conservative approach and assumed that **projects would be 50% effective** in reducing sediment and nutrients from the stream reach." " The Panel felt that **efficiencies greater than 50% should be allowed for projects that have shown through monitoring** that the higher rates can be **<u>justified subject to approval by the states."</u>**

  - ***Step 1.*** *Estimate stream sediment erosion rate*
    - Cross-sections or bank pins
    - BANCS (Bank Assessment for Nonpoint Source Consequences of Sediment)

  - ***Step 2.*** *Convert stream bank erosion to nutrient loading*

  - ***Step 3. Estimate stream restoration efficiency***

Protocol 1 – Current Project

•50% Efficiency

	Stream Length	TSS	P	N
	lf	ton/year	lbs/year	lbs/year
Main Stream (Left and Right Banks)	4309	95.0	551	1197
Tributaries	1509	15.1	87	190
	5818	**110.1**	**639**	**1387**

•85% Efficiency

	Stream Length	TSS	P	N
	lf	ton/year	lbs/year	lbs/year
Main Stream (Left and Right Banks)	4309	161.5	937	2035
Tributaries	1509	25.6	149	323
	5818	**187.2**	**1086**	**2358**

P= 1086 – 639 = **447** lbs/year increase!!

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Projects not considered under the Stream Restoration BMP according to DEQ.

- If it doesn't meet stream restoration requirements, and can not be assigned to another BMP category the permittee can always contact DEQ and discuss a alternative project. DEQ will review these alternative type projects on a case by case basis. The more information provided, rationale, calculations, etc. the quicker DEQ can respond to the request.

- Other BMP examples utilized in the Coastal Plain:
  - Shoreline Stabilization
  - Buffers
  - Swales
  - Wet ponds
  - Constructed wetlands

Locality inspections after any post-construction permit required monitoring expires.

- Stream Restoration BMP post permit monitoring
  - Visual inspections for failures
  - Photographs
  - Optional site visit with DEQ Stream Restoration Specialist

- New monitoring guidance
  - Recommended Methods to Verify Stream Restoration Practices Built for Pollutant Crediting in the Chesapeake Bay Watershed

CBP APPROVED MEMO

Recommended Methods to Verify Stream Restoration Practices Built for Pollutant Crediting in the Chesapeake Bay Watershed

Submitted By:
Stream Restoration Group 1: Verification

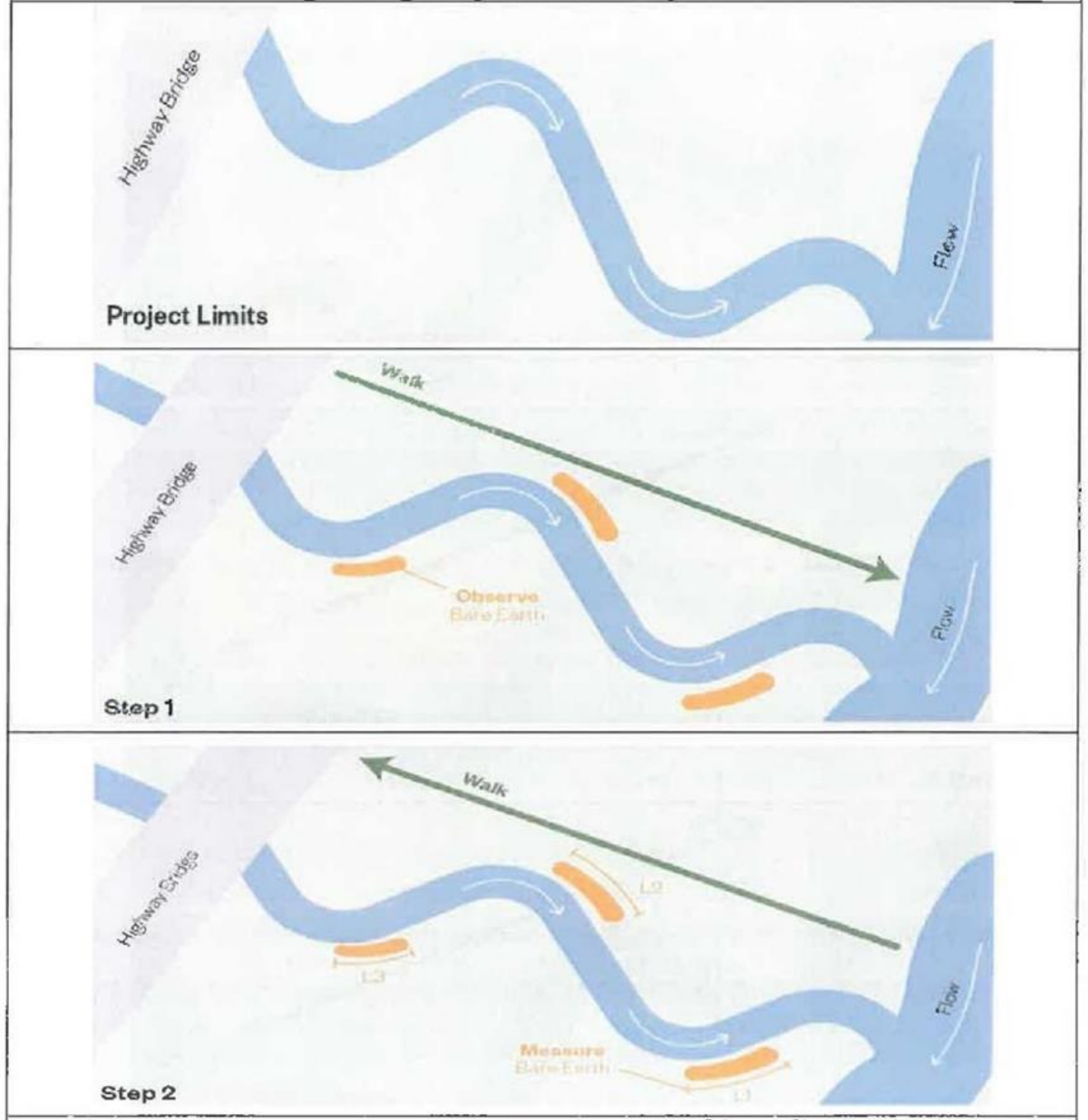
Josh Burch, Scott Cox, Sandra Davis,
Meghan Fellows, Kathy Hoverman, Neely Law,
Kip Mumaw, Jennifer Rauhofer, Tim Schueler and Rich Starr

Approved by the Urban Stormwater Work Group
of the Chesapeake Bay Program

Date: June 18, 2019

https://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2019/07/Approved-Verification-Memo-061819.pdf

Figure 2:
Fieldwork for Inspecting Projects to Verify Protocol 1 Performance



Graphic credit: Cassie Frye, Hazen

Protocol 1 Verification

- Walk project area
- Note any problem areas
- Measure problem areas
- Calculate percentage of impacted areas

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Section 6: Thresholds for Defining Management Actions

The project is analyzed to determine if the degree of change, relative to the original design, is severe enough to warrant management action (Table 7). All stream restoration projects fall into one of three possible categories:

1. Functioning (Pass)
2. Showing Major Compromise (Action Needed)
3. Project Failure (Fail)

Table 7:
Framework for Relating Reach Conditions to Management Decisions

Status	*% of Failing Project Reach*	*Inspections*	*Management Actions*
Functioning or Showing Minor Compromise	**0 to 10%**	Re-inspect in 5 years	None Needed Credit Renewed for 5 Years
Showing Major Compromise	**20 to 40%**	Conduct immediate forensic investigation to identify cause(s)	Do project maintenance and repairs, as warranted
Project Failure	**50% or more**	Lose credit and abandon the project or reconstruct a new stable channel	

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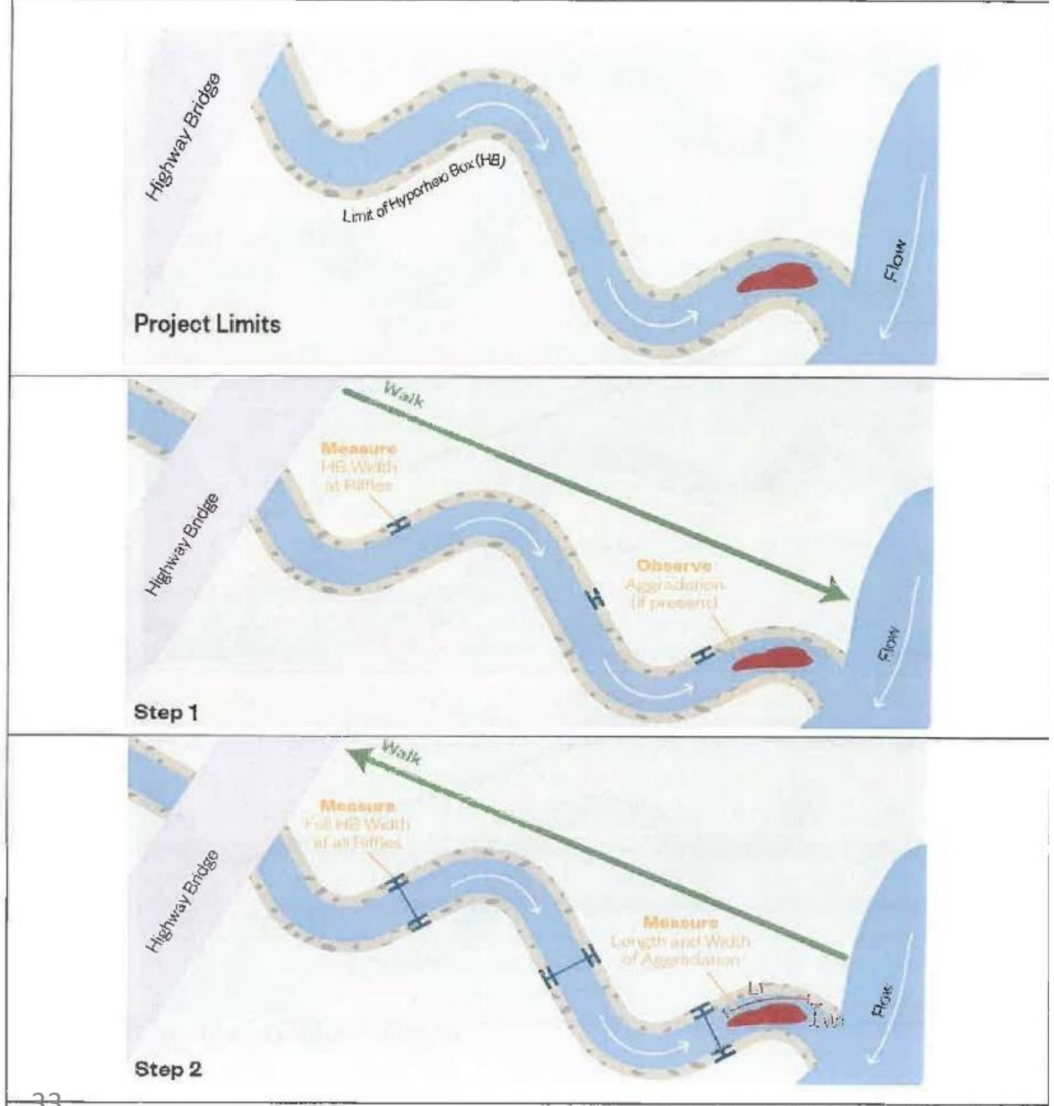
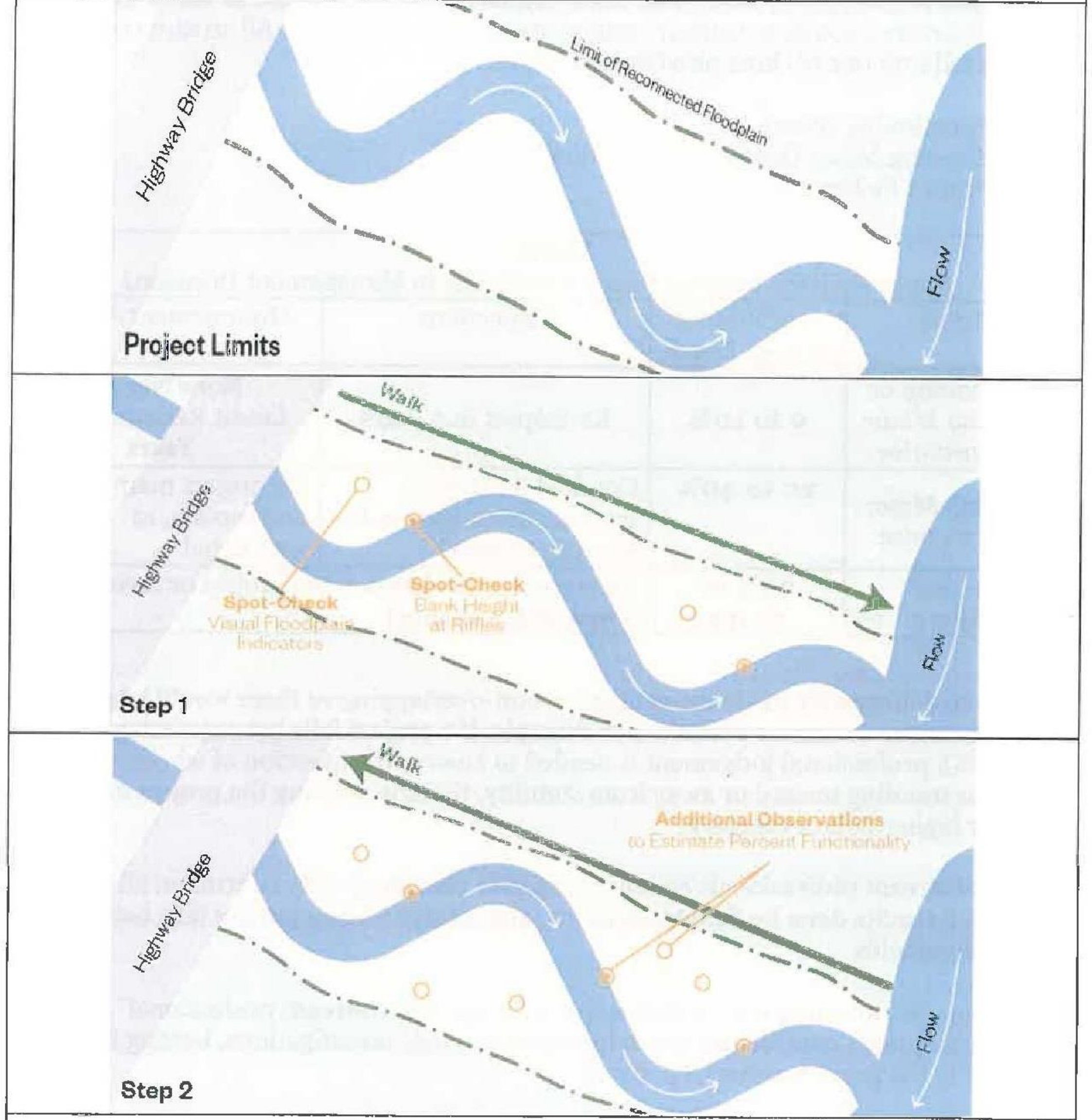
Figure 3: Fieldwork for Inspecting Projects to Verify Protocol 2 Performance



Graphic credit: Cassie Frye, Hazen

Figure 4: Fieldwork for Inspecting Projects to Verify Protocol 3 Performance



Graphic credit: Cassie Frye, Hazen

References to documents

- https://www.chesapeakebay.net/channel_files/37043/approval_draft_outfall_restoration_memo_070119.pdf
- https://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2019/07/Approved-Verification-Memo-061819.pdf
- Email me brock.reggi@deq.virginia.gov

DEQ

Questions?

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Hypothetical Protocol 1: Average Reductions per BEHI/NBS Ratings

- Pre and Post-Construction Estimates of Erosion Rates
- RESTORATION REDUCES BANK HEIGHT BY 50% POST CONSTRUCTION

Reach ID	Bank Length	Bank Height	Bank Area	NBS Rating	BEHI Rating	Predicted Erosion Rate	Predicted Erosion Rate	Bank TSS Load ! Year	Bank Erosion Rate	Bank TP Load ! Year	Annual TP Load	Average Pre-Const TP Load
Bank #	Ft	Ft	SF			ft/year	CF/year	Ton/year	Tons/Ft/year	lbs./year	lbs/Ft/year	
Pre-Const	100	5	500	High	High	1	500	24.08	0.24	25.28	0.253	15.67
Pre-Const	100	5	500	High	Moderate	0.8	400	19.26	0.19	20.22	0.202	
Pre-Const	100	5	500	Moderate	High	0.6	300	14.45	0.14	15.17	0.152	
Pre-Const	100	5	500	Low	High	0.4	200	9.63	0.10	10.11	0.101	
Pre-Const	100	5	500	Moderate	Moderate	0.3	150	7.22	0.07	7.58	0.076	
Post-Const	100	2.5	250	Low	Moderate	0.12	30	1.44	0.01	1.52	0.015	0.97
Post-Const	100	2.5	250	Moderate	Low	0.09	23	1.08	0.01	1.14	0.011	
Post-Const	100	2.5	250	low	low	0.02	5	0.24	0.00	0.25	0.003	

EFFECIENCIES

- 80% The LOWEST reduction Post Construction (Mod/Mod to Low/Mod)
- 99% The Greatest Reduction Post Construction (High/High to Low/Low)
- **94% Average Reduction Post Construction**